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Terakami et al.

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(54) **LIGHT-EMITTING DEVICE AND METHOD OF MANUFACTURING THE SAME**

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H01L 33/50 (2010.01)

(52) **U.S. Cl.**
CPC ***H01L 25/0753*** (2013.01); *H01L 33/504* (2013.01); *H01L 2924/0002* (2013.01)

(58) **Field of Classification Search**
CPC combination set(s) only.
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2002/0185965	A1*	12/2002	Collins et al.	313/501
2006/0038477	A1	2/2006	Tamaki et al.	
2007/0170454	A1*	7/2007	Andrews	257/100
2008/0137331	A1*	6/2008	Kaneko et al.	362/231
2010/0207134	A1	8/2010	Tanaka et al.	
2011/0278605	A1	11/2011	Agatani et al.	
2012/0008318	A1	1/2012	Ishiwata et al.	

FOREIGN PATENT DOCUMENTS

JP	2004-071726	A	3/2004
JP	2009-224074	A	10/2009
JP	2011-204659	A	10/2011
JP	2012-004519	A	1/2012

* cited by examiner

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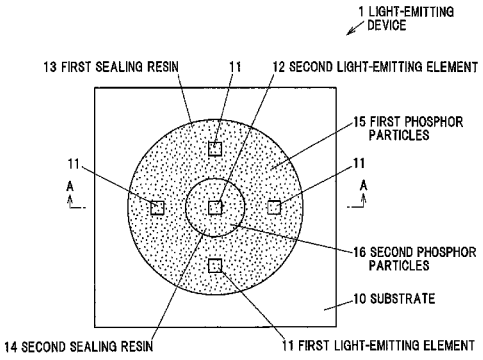
(57) **ABSTRACT**

A light-emitting device includes a first light-emitting element disposed on a substrate, a convex-shaped first sealing resin that includes an annular portion formed in a closed annular shape in a top view and seals the first light-emitting element, a second light-emitting element disposed on the substrate in a region surrounded by the annular portion of the first sealing resin, and a second sealing resin filled in the region surrounded by the annular portion so as to seal the second light-emitting element. One of the first and second sealing resin includes a phosphor particle or the first and second sealing resins include a phosphor particle to emit a different fluorescent color from each other.

12 Claims, 8 Drawing Sheets



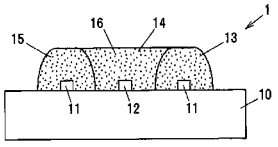


FIG.1A

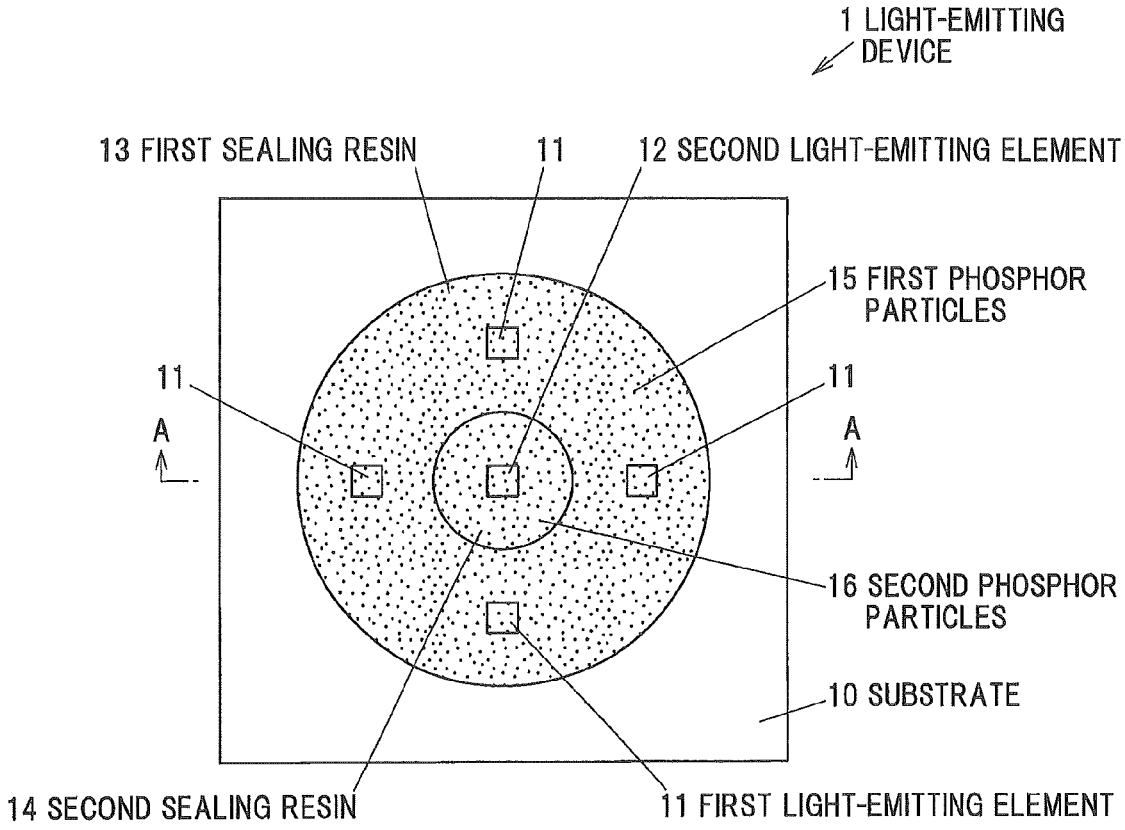
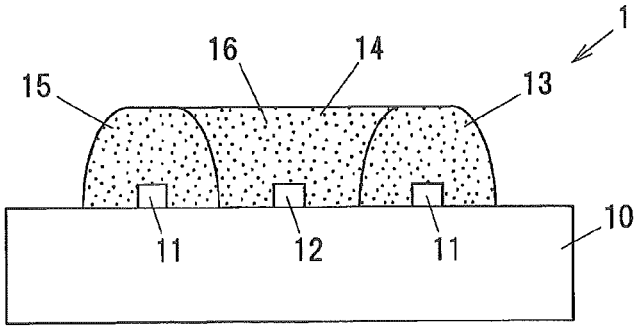

1 LIGHT-EMITTING DEVICE
13 FIRST SEALING RESIN
11
12 SECOND LIGHT-EMITTING ELEMENT
15 FIRST PHOSPHOR PARTICLES
11
A
11
A
16 SECOND PHOSPHOR PARTICLES
10 SUBSTRATE
14 SECOND SEALING RESIN
11 FIRST LIGHT-EMITTING ELEMENT

FIG.1B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11
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FIG.2A

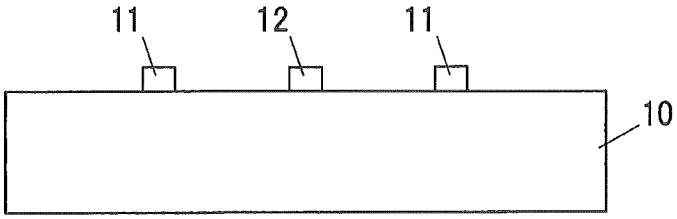


FIG.2B

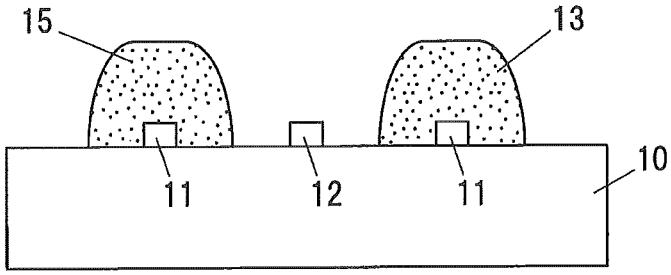


FIG.2C

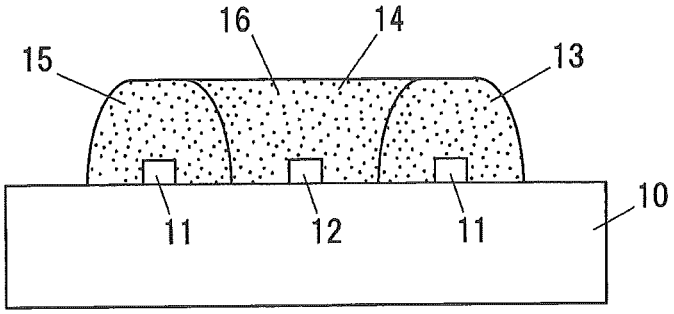


FIG.3A

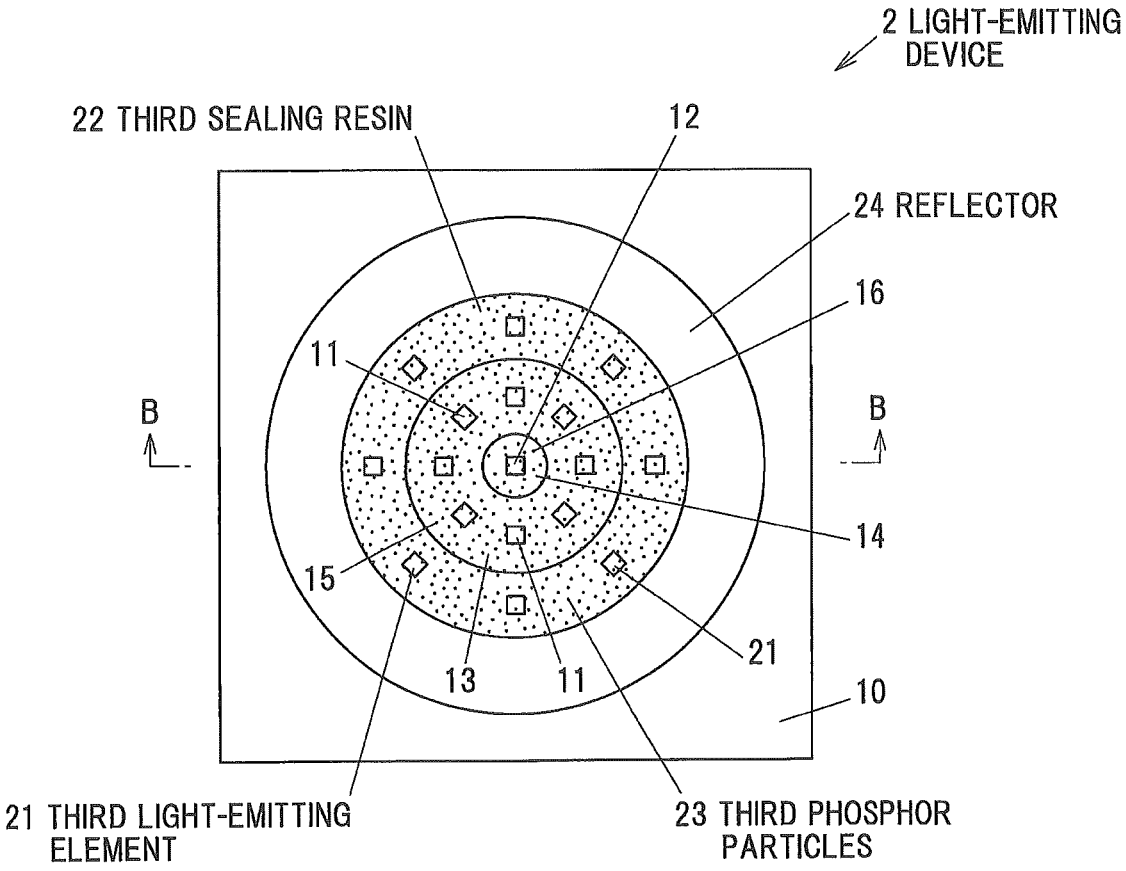
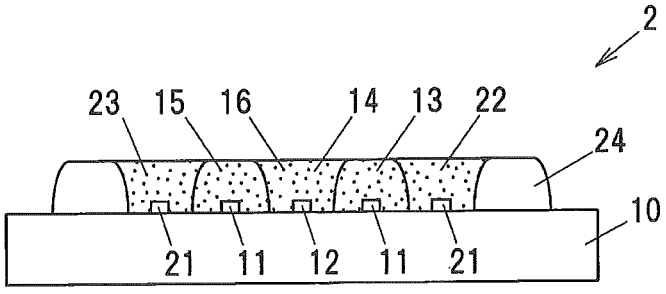

2 LIGHT-EMITTING DEVICE
22 THIRD SEALING RESIN
12
24 REFLECTOR
16
11
B
B
14
15
21
13
11
10
21 THIRD LIGHT-EMITTING ELEMENT
23 THIRD PHOSPHOR PARTICLES

FIG.3B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11
12
11
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FIG.4A

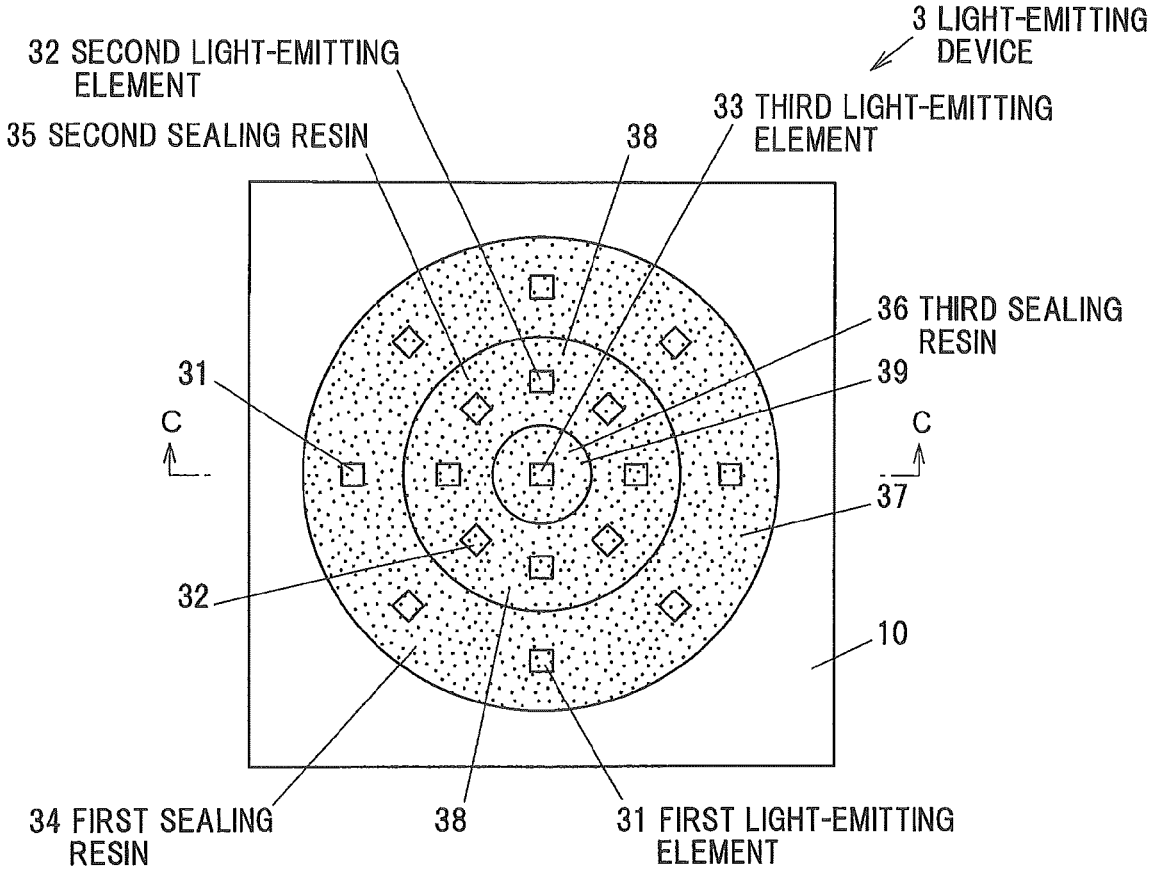
3 LIGHT-EMITTING DEVICE
32 SECOND LIGHT-EMITTING ELEMENT
35 SECOND SEALING RESIN
38
33 THIRD LIGHT-EMITTING ELEMENT
36 THIRD SEALING RESIN
39
31
C
C
37
32
10
34 FIRST SEALING RESIN
38
31 FIRST LIGHT-EMITTING ELEMENT

FIG.4B

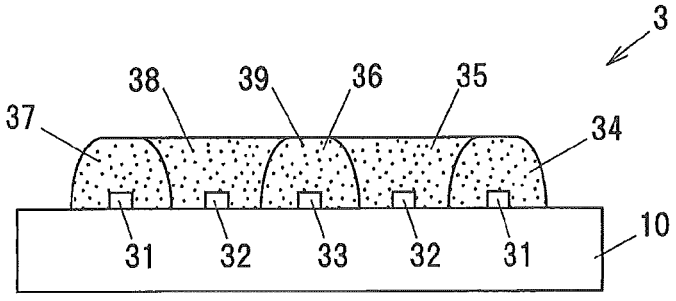
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FIG.5A

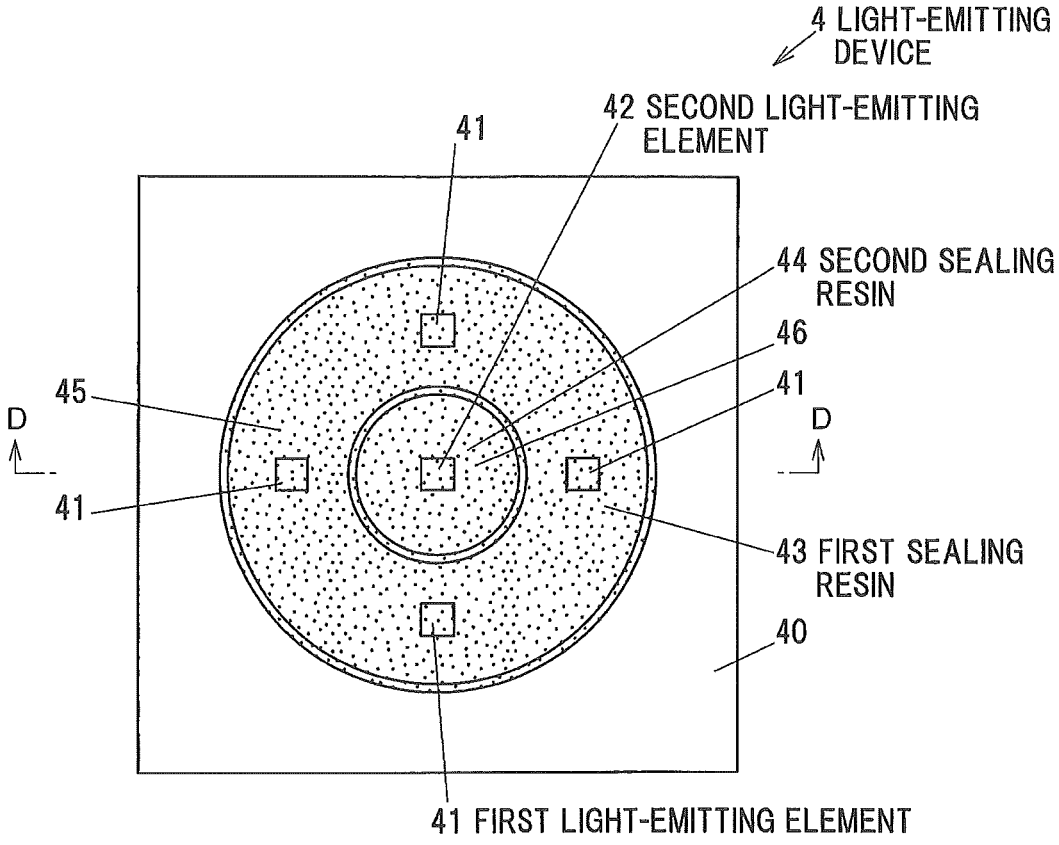
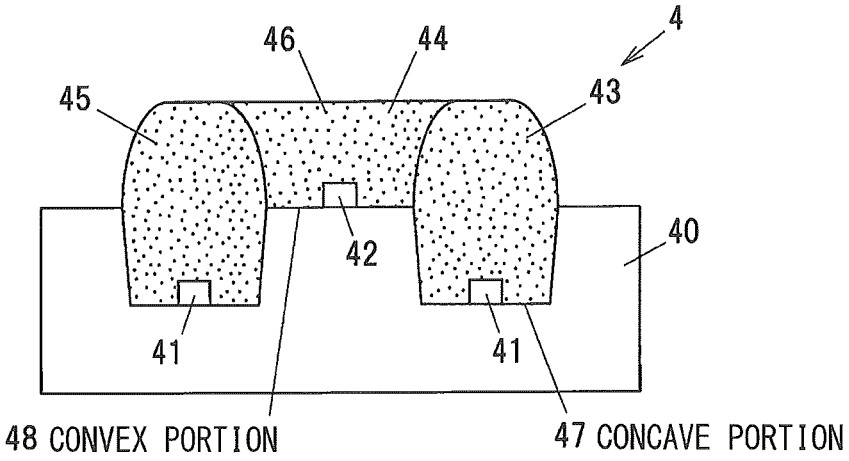

4 LIGHT-EMITTING DEVICE
42 SECOND LIGHT-EMITTING ELEMENT
41
44 SECOND SEALING RESIN
46
41
45
D
D
41
43 FIRST SEALING RESIN
40
41 FIRST LIGHT-EMITTING ELEMENT

FIG.5B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44
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43
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42
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41
48 CONVEX PORTION
47 CONCAVE PORTION

FIG.6A

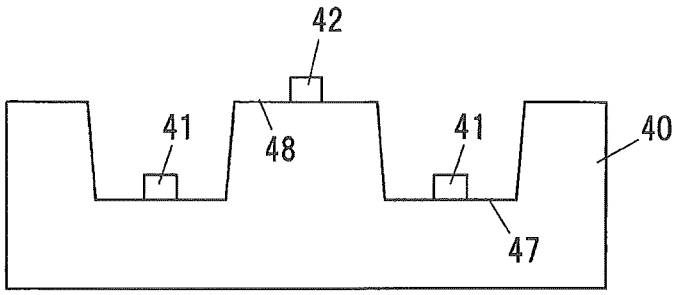


FIG.6B

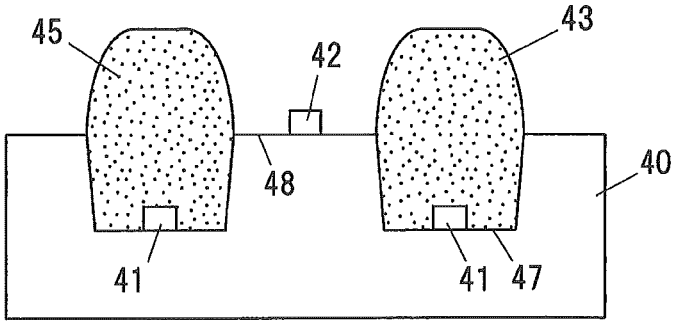


FIG.6C

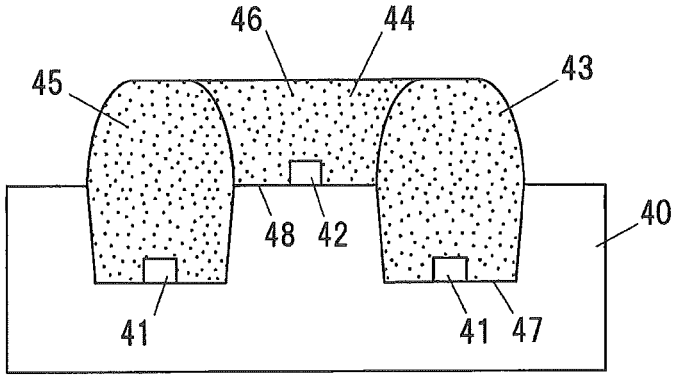
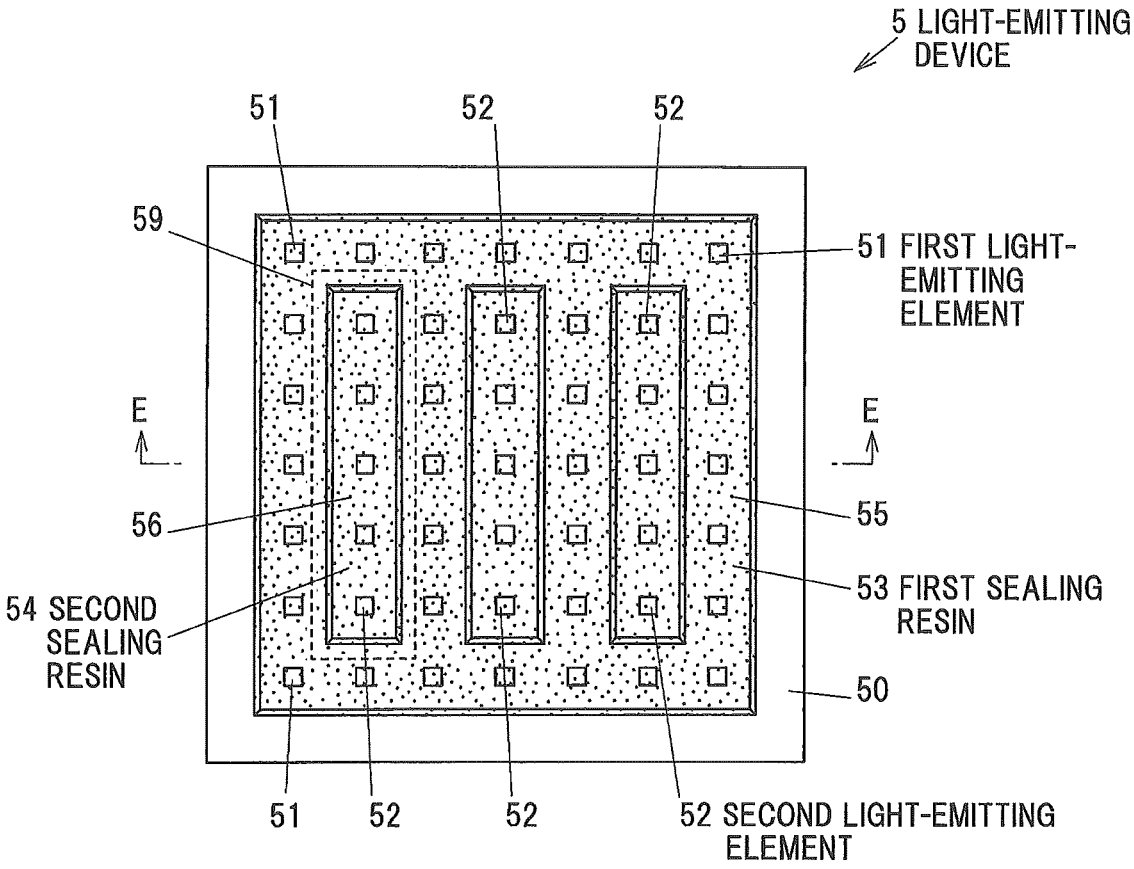


FIG.7A


5 LIGHT-EMITTING DEVICE
51
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51 FIRST LIGHT-EMITTING ELEMENT
E
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54 SECOND SEALING RESIN
53 FIRST SEALING RESIN
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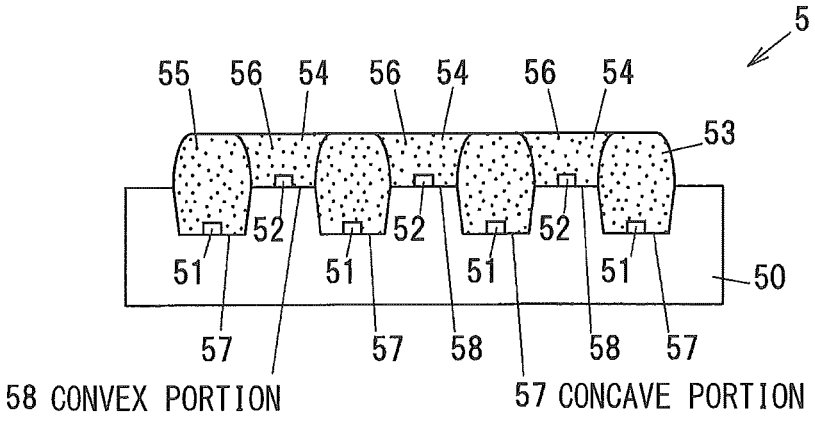
52 SECOND LIGHT-EMITTING ELEMENT

FIG.7B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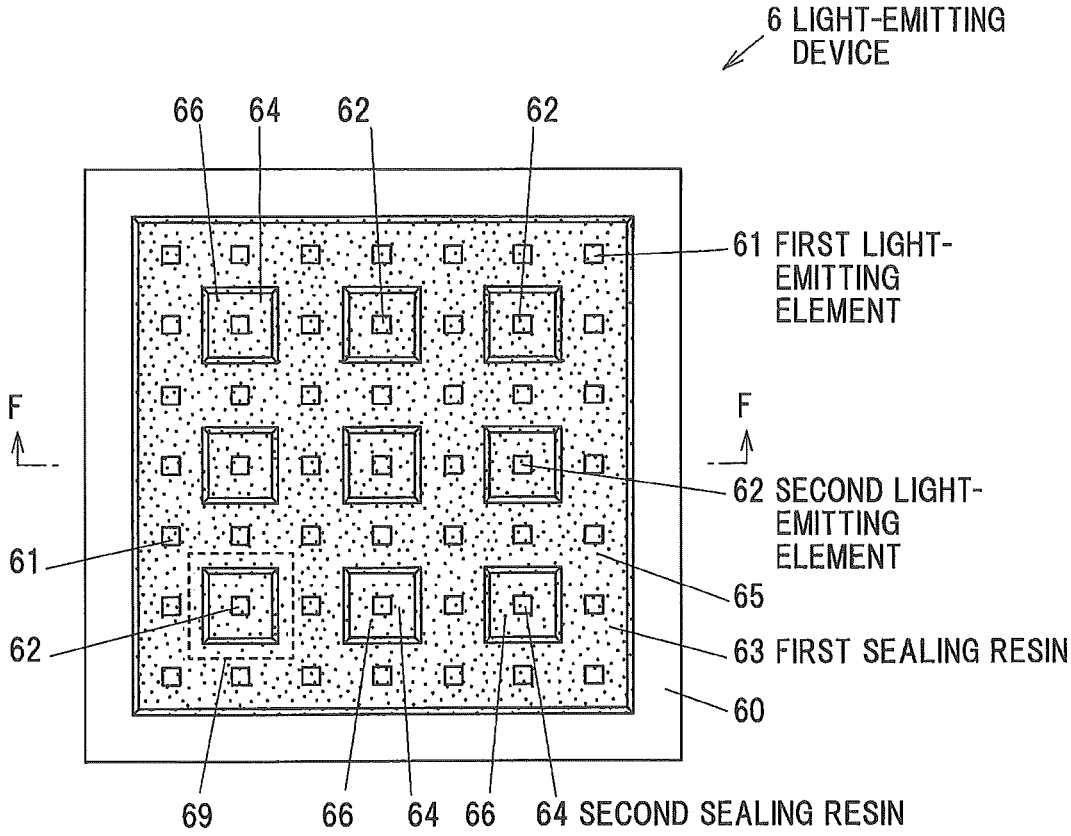
58 CONVEX PORTION
57 CONCAVE PORTION

FIG.8A


6 LIGHT-EMITTING DEVICE
66
64
62
62
61 FIRST LIGHT-EMITTING ELEMENT
F
F
62 SECOND LIGHT-EMITTING ELEMENT
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63 FIRST SEALING RESIN
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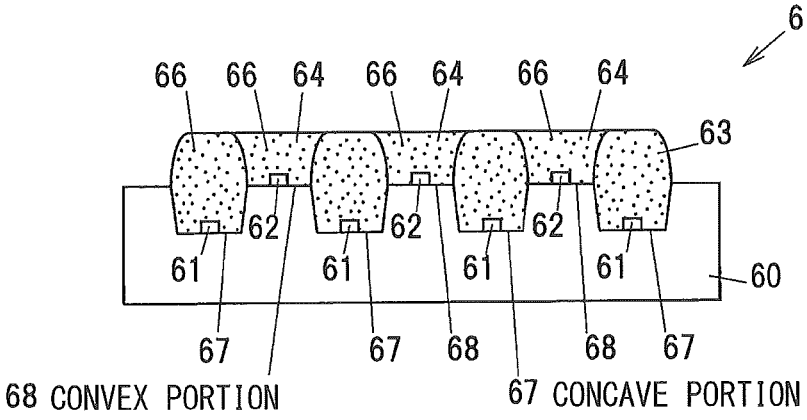
64 SECOND SEALING RESIN

FIG.8B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68 CONVEX PORTION
67 CONCAVE PORTION

LIGHT-EMITTING DEVICE AND METHOD OF MANUFACTURING THE SAME

The present application is based on Japanese patent application Nos. 2013-191636 and 2014-055244 filed on Sep. 17, 2013 and Mar. 18, 2014, respectively, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a light-emitting device and a method of manufacturing the light-emitting device.

2. Description of the Related Art

Light-emitting devices and lighting systems having plural light-emitting portions to emit different colors are known (see e.g. JP-A-2004-071726, JP-A-2009-224074, JP-A-2011-204659 and JP-A-2012-004519).

JP-A-2004-071726 discloses a light-emitting device that a stepped portion is provided in a package and LED chips are placed on upper and lower steps. A resin for sealing the LED chips on the upper step and a resin for sealing the LED chips on the lower step include phosphors respectively emitting different fluorescent colors.

JP-A-2009-224074 discloses a light-emitting device that a blue LED chip covered with a resin including red phosphor, a blue LED chip covered with a resin including green phosphor and a blue LED chip covered with a resin including blue phosphor are provided on a substrate and these resins including different phosphors are formed away from each other.

JP-A-2011-204659 discloses a lighting system that a red LED chip, a green LED chip, a blue LED chip and a blue LED chip covered with a resin including yellow phosphor are provided on a substrate.

JP-A-2012-004519 discloses a light-emitting device that has a resin frame provided on a substrate, a resin partition wall for dividing a portion surrounded by the resin frame into two zones, a blue LED chip placed in one zone and sealed with a resin including red phosphor and a blue LED chip placed in another zone and sealed with a resin including yellow phosphor. Since the two zones are separate from each other by the resin partition wall, the resin including red phosphor and the resin including yellow phosphor can be prevented from mixing with each other upon filling the resins. The resin frame and the resin partition wall are formed of a resin with a light reflecting or shielding property.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a light-emitting device that has plural light-emitting portions to emit different colors and is suited to simplification of a manufacturing process thereof and reduction in occupied area, as well as a method of manufacturing the light-emitting device.

(1) According to one embodiment of the invention, a light-emitting device comprises:

a first light-emitting element disposed on a substrate;

a convex-shaped first sealing resin that comprises an annular portion formed in a closed annular shape in a top view and seals the first light-emitting element;

a second light-emitting element disposed on the substrate in a region surrounded by the annular portion of the first sealing resin; and

a second sealing resin filled in the region surrounded by the annular portion so as to seal the second light-emitting element,

wherein one of the first and second sealing resin includes a phosphor particle or the first and second sealing resins include a phosphor particle to emit a different fluorescent color from each other.

In the above embodiment (1) of the invention, the following modifications and changes can be made.

(i) A resin material of the first sealing resin has a higher thixotropy before curing than a resin material of the second sealing resin.

(ii) The substrate comprises a concave portion and a convex portion on an upper surface thereof, wherein the first light-emitting element is disposed on a bottom surface of the concave portion, wherein the first sealing resin is provided in the concave portion and above the concave portion, and wherein the second light-emitting element is disposed on an upper surface of the convex portion.

(iii) An emission wavelength of the first light-emitting element is longer than that of the second light-emitting element.

(2) According to another embodiment of the invention, a method of manufacturing a light-emitting device comprises:

placing first and second light-emitting elements on a substrate;

forming a convex-shaped first sealing resin comprising an annular portion formed in a closed annular shape in a top view by stacking up a first resin on the substrate so that the first light-emitting element is sealed and the second light-emitting element is surrounded by the annular portion; and

forming a second sealing resin for sealing the second light-emitting element by filling a region surrounded by the annular portion with a second resin by using the annular portion as a dam,

wherein one of the first and second sealing resin includes a phosphor particle or the first and second sealing resins include a phosphor particle to emit a different fluorescent color from each other.

In the above embodiment (2) of the invention, the following modifications and changes can be made.

(iv) The first resin has a higher thixotropy than the second resin.

(v) The substrate comprises a concave portion and a convex portion on an upper surface thereof, wherein the first light-emitting element is disposed on a bottom surface of the concave portion, wherein the second light-emitting element is disposed on an upper surface of the convex portion, and wherein the first resin is filled in the concave portion and is further stacked up above the concave portion so as to form the first sealing resin.

(vi) An emission wavelength of the first light-emitting element is longer than that of the second light-emitting element.

Effects of the Invention

According to one embodiment of the invention, a light-emitting device can be provided that has plural light-emitting portions to emit different colors and is suited to simplification of a manufacturing process thereof and reduction in occupied area, as well as a method of manufacturing the light-emitting device.

BRIEF DESCRIPTION OF THE DRAWINGS

Next, the present invention will be explained in more detail in conjunction with appended drawings, wherein:

FIG. **1**A is a top view showing a light-emitting device in a first embodiment;

FIG. **1**B is a vertical cross-sectional view showing the light-emitting device taken on line A-A of FIG. **1**A;

FIGS. **2**A to **2**C are vertical cross-sectional views showing a manufacturing process of the light-emitting device in the first embodiment;

FIG. **3**A is a top view showing a light-emitting device in a second embodiment;

FIG. **3**B is a vertical cross-sectional view showing the light-emitting device taken on line B-B of FIG. **3**A;

FIG. **4**A is a top view showing a light-emitting device in a third embodiment;

FIG. **4**B is a vertical cross-sectional view showing the light-emitting device taken on line C-C of FIG. **4**A;

FIG. **5**A is a top view showing a light-emitting device in a fourth embodiment;

FIG. **5**B is a vertical cross-sectional view showing the light-emitting device taken on line D-D of FIG. **5**A;

FIGS. **6**A to **6**C are vertical cross-sectional views showing a manufacturing process of the light-emitting device in the fourth embodiment;

FIG. **7**A is a top view showing a light-emitting device in a fifth embodiment;

FIG. **7**B is a vertical cross-sectional view showing the light-emitting device taken on line E-E of FIG. **7**A;

FIG. **8**A is a top view showing a light-emitting device in a sixth embodiment; and

FIG. **8**B is a vertical cross-sectional view showing the light-emitting device taken on line F-F of FIG. **8**A.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

First Embodiment

Structure of Light-Emitting Device

FIG. **1**A is a top view showing a light-emitting device **1** in the first embodiment. FIG. **1**B is a vertical cross-sectional view showing the light-emitting device **1** taken on line A-A of FIG. **1**A.

The light-emitting device **1** has a substrate **10**, first light-emitting elements **11** placed on the substrate **10**, a convex-shaped first sealing resin **13** which has a closed annular shape in a top view and seals the first light-emitting elements **11**, a second light-emitting element **12** arranged on the substrate **10** in a region surrounded by the first sealing resin **13**, and a second sealing resin **14** filled in the region surrounded by the first sealing resin **13** to seal the second light-emitting element **12**.

Either the first sealing resin **13** or the second sealing resin **14** includes phosphor particles, or the first sealing resin **13** and the second sealing resin **14** respectively include phosphor particles emitting different fluorescent colors. In the example shown in FIGS. **1**A and **1**B, the first sealing resin **13** and the second sealing resin **14** respectively include first phosphor particles **15** and second phosphor particles **16**.

The substrate **10** is, e.g., a circuit board or a lead frame inserted board.

The first light-emitting element **11** and the second light-emitting element **12** are, e.g., an LED chip having a chip substrate and a crystal layer which includes cladding layers and a light-emitting layer sandwiched therebetween. The first light-emitting element **11** and the second light-emitting element **12** may be a face-up LED chip with the crystal layer facing upward or a face-down LED chip with the crystal layer facing downward. Alternatively, light-emitting elements other than LED chips, such as laser diode, may be used.

The first light-emitting elements **11** and the second light-emitting element **12** are connected to a non-illustrated conductive member such as a wiring pattern or a lead frame included in the substrate **10** and power is supplied separately to the first light-emitting element **11** and the second light-emitting element **12** through the conductive member.

The first sealing resin **13** and the second sealing resin **14** is formed of a transparent resin, e.g., a silicone-based resin or an epoxy-based resin, etc.

Since the first sealing resin **13** is formed by stacking up a resin on the substrate **10**, thixotropy of the resin before curing is preferably high. When thixotropy is high, an increase in viscosity after formation is large and the shape thereof is thus likely to be kept until the resin is cured.

On the other hand, the second sealing resin **14** is formed by filling a region surrounded by the first sealing resin **13** with a resin using the first sealing resin **13** as a dam and then curing the resin. Accordingly, if the resin has high thixotropy before curing, it is difficult to appropriately fill the resin.

Therefore, the resin as a material of the first sealing resin **13** preferably has higher thixotropy before curing than the resin as a material of the second sealing resin **14**.

Since the second sealing resin **14** is formed after the first sealing resin **13** is completely or substantially cured, the first sealing resin **13** and the second sealing resin **14** are not mixed with each other. In other words, phosphor particles included in each of the first sealing resin **13** and the second sealing resin **14** do not move into the other sealing resin.

The following Table 1 shows examples of combinations of emission color of light-emitting element and fluorescent color of phosphor particles (combinations of emission color of the first light-emitting element **11** and fluorescent color of the first phosphor particles **15**, or combinations of emission color of the second light-emitting element **12** and fluorescent color of the second phosphor particles **16**). Note that, "nil" in Table means that phosphor particles (the first phosphor particles **15** or the second phosphor particles **16**) are not used. In addition, "blue+green+red", "blue+green+yellow+red", "blue+yellow+red", "blue+yellow", "green+red" and "yellow+red" mean that plural types of phosphor particles each emitting different color are used in combination.

TABLE 1

	Light-emitting element	Phosphor particles
1	Violet	not included
2	Blue	not included
3	Green	not included
4	Red	not included
5	Violet	Blue
6	Violet	Green
7	Violet	Red
8	Violet	Yellow
9	Blue	Green
10	Blue	Red
11	Blue	Yellow
12	Violet	Blue + Green + Red
13	Violet	Blue + Green + Yellow + Red
14	Violet	Blue + Yellow + Red
15	Violet	Blue + Yellow
16	Blue	Green + Red
17	Blue	Yellow + Red
18	Green	Red
19	Green	Yellow

Appropriate selection of the combination of the first light-emitting element **11** and the first phosphor particles **15** and the combination of the second light-emitting element **12** and the second phosphor particles **16** allows emission color of a light-emitting portion composed of the first light-emitting element **11** and the first sealing resin **13** including the first phosphor particles **15** and emission color of a light-emitting portion

composed of the second light-emitting element **12** and the second sealing resin **14** including the second phosphor particles **16** to be arbitrarily set, and it is thereby possible to obtain the light-emitting device **1** which emits light of desired color.

For example, there are phosphors with high blue-light excitation efficiency and those with high violet-light excitation efficiency. It is possible to appropriately select the first phosphor particles **15** depending on excitation characteristics of these phosphors. When some of light-emitting elements included in the light-emitting device **1** emit violet light, violet color is added to emission light of the light-emitting device **1** and color rendering properties of the light-emitting device **1** are thereby improved.

In addition, since power is supplied separately to the first light-emitting element **11** and the second light-emitting element **12**, it is possible to arbitrarily control light intensity of each light-emitting element. This allows emission chromaticity or color rendering properties to be finely adjusted. In addition, it is possible to cause only one of the first light-emitting element **11** and the second light-emitting element **12** to emit light.

Manufacturing Process of Light-Emitting Device

An example of a manufacturing process of the light-emitting device **1** will be described below.

FIGS. **2**A to **2**C are vertical cross-sectional views showing a manufacturing process of the light-emitting device **1** in the first embodiment.

Firstly, as shown in FIG. **2**A, the first light-emitting elements **11** and the second light-emitting element **12** are placed on the substrate **10**.

Next, as shown in FIG. **2**B, a resin including the first phosphor particles **15** is stacked up on the substrate **10** so as to seal the first light-emitting elements **11** and to surround the second light-emitting element **12**, thereby forming the first sealing resin **13**.

In detail, for example, a liquid resin including the first phosphor particles **15** is stacked up on the substrate **10** by dripping, etc., and is then cured, thereby forming the first sealing resin **13**. Here, by using a highly thixotropic resin as the resin of the first sealing resin **13**, it is possible to suppress deformation of the first sealing resin **13** before curing.

Next, as shown in FIG. **2**C, a resin including the second phosphor particles **16** is filled in a region surrounded by the first sealing resin **13** using the first sealing resin **13** as a dam and is then cured, thereby forming the second sealing resin **14** which seals the second light-emitting element **12**. Here, the resin of the second sealing resin **14** is filled after the first sealing resin **13** is cured to the extent that the first sealing resin **13** is not mixed with the resin of the second sealing resin **14**.

Second Embodiment

The second embodiment is different from the first embodiment in that the light-emitting device is provided with a reflector. It should be noted that the explanation of the same features as the first embodiment will be omitted or simplified.

Structure of Light-Emitting Device

FIG. **3**A is a top view showing a light-emitting device **2** in the second embodiment. FIG. **3**B is a vertical cross-sectional view showing the light-emitting device **2** taken on line B-B of FIG. **3**A.

In the same manner as the light-emitting device **1** in the first embodiment, the light-emitting device **2** has the substrate **10**, the first light-emitting elements **11** placed on the substrate **10**, the convex-shaped first sealing resin **13** which has a closed annular shape in a plan view and seals the first light-emitting elements **11**, the second light-emitting element **12** arranged on the substrate **10** in a region surrounded by the first sealing resin **13**, and the second sealing resin **14** filled in the region surrounded by the first sealing resin **13** to seal the second light-emitting element **12**.

The light-emitting device **2** further includes a reflector **24** having a closed annular shape in a top view and surrounding the first sealing resin **13**, third light-emitting elements **21** placed on the substrate **10** in a region between the first sealing resin **13** and the reflector **24**, and a third sealing resin **22** filled in the region between the first sealing resin **13** and the reflector **24** to seal the third light-emitting elements **21**.

Either the first sealing resin **13** or the second sealing resin **14** includes phosphor particles, or the first sealing resin **13** and the second sealing resin **14** respectively include phosphor particles emitting different fluorescent colors. In addition, either the first sealing resin **13** or the third sealing resin **22** includes phosphor particles, or the first sealing resin **13** and the third sealing resin **22** respectively include phosphor particles emitting different fluorescent colors. In the example shown in FIGS. **3**A and **3**B, the first sealing resin **13**, the second sealing resin **14** and the third sealing resin **22** respectively include the first phosphor particles **15**, the second phosphor particles **16** and third phosphor particles **23**.

The third light-emitting element **21** is the same light-emitting element as the first light-emitting element **11** and the second light-emitting element **12**.

The first light-emitting elements **11**, the second light-emitting element **12** and the third light-emitting elements **21** are connected to a non-illustrated conductive member such as a wiring pattern or a lead frame included in the substrate **10** and power is supplied separately to the first light-emitting elements **11**, the second light-emitting element **12** and the third light-emitting elements **21** through the conductive member.

The reflector **24** is formed of, e.g., a thermoplastic resin such as polyphthalamide resin, LCP (Liquid Crystal Polymer) or PCT (Polycyclohexylene Dimethylene Terephalate) or a thermosetting resin such as silicone resin, modified silicone resin, epoxy resin or modified epoxy resin. The reflector **24** may include light-reflecting particles of titanium dioxide, etc., to improve light reflectance.

The third sealing resin **22** is formed by filling the region between the first sealing resin **13** and the reflector **24** with a resin using the first sealing resin **13** and the reflector **24** as dams and then curing the resin. Accordingly, if the resin has high thixotropy before curing, it is difficult to appropriately fill the resin.

Therefore, the resin as a material of the third sealing resin **22** preferably has lower thixotropy before curing than the resin as a material of the first sealing resin **13**. The resin as a material of the third sealing resin **22** may be the same as that of the second sealing resin **14**.

Since the second sealing resin **14** and the third sealing resin **22** are formed after the first sealing resin **13** is completely or substantially cured, the first sealing resin **13**, the second sealing resin **14** and the third sealing resin **22** are not mixed with each other. In other words, phosphor particles included in each of the first sealing resin **13**, the second sealing resin **14** and the third sealing resin **22** do not move into the other sealing resins.

Third Embodiment

The third embodiment is different from the first embodiment in that the third sealing resin is formed on the inner side of the second sealing resin. It should be noted that the explanation of the same features as the first embodiment will be omitted or simplified.

Structure of Light-Emitting Device

FIG. **4**A is a top view showing a light-emitting device **3** in the third embodiment. FIG. **4**B is a vertical cross-sectional view showing the light-emitting device **3** taken on line C-C of FIG. **4**A.

The light-emitting device **3** has the substrate **10**, first light-emitting elements **31** placed on the substrate **10**, a convex-shaped first sealing resin **34** which has a closed annular shape in a top view and seals the first light-emitting elements **31**, a third light-emitting element **33** arranged on the substrate **10** in a region surrounded by the first sealing resin **34**, a convex-shaped third sealing resin **36** for sealing the light-emitting element **33**, second light-emitting elements **32** placed on the substrate **10** in a region between the first sealing resin **34** and the third sealing resin **36**, and a second sealing resin **35** filled in the region between the first sealing resin **34** and the third sealing resin **36** to seal the second light-emitting elements **32**.

Either the first sealing resin **34** or the second sealing resin **35** includes phosphor particles, or the first sealing resin **34** and the second sealing resin **35** respectively include phosphor particles emitting different fluorescent colors. In addition, either the first sealing resin **34** or the third sealing resin **36** includes phosphor particles, or the first sealing resin **34** and the third sealing resin **36** respectively include phosphor particles emitting different fluorescent colors. In the example shown in FIGS. **4**A and **4**B, the first sealing resin **34**, the second sealing resin **35** and the third sealing resin **36** respectively include first phosphor particles **37**, second phosphor particles **38** and third phosphor particles **39**.

The third light-emitting element **33** is the same light-emitting element as the first light-emitting element **31** and the second light-emitting element **32**.

The first light-emitting elements **31**, the second light-emitting elements **32** and the third light-emitting element **33** are connected to a non-illustrated conductive member such as a wiring pattern or a lead frame included in the substrate **10** and power is supplied separately to the first light-emitting elements **31**, the second light-emitting elements **32** and the third light-emitting element **33** through the conductive member.

Since the first sealing resin **34** and the third sealing resin **36** are formed by stacking up a resin on the substrate **10**, thixotropy of the resin before curing is preferably high. When thixotropy is high, an increase in viscosity after formation is large and the shape thereof is thus likely to be kept until the resin is cured.

The second sealing resin **35** is formed by filling a region between the first sealing resin **34** and the third sealing resin **36** with a resin using the first sealing resin **34** and the third sealing resin **36** as dams and then curing the resin. Accordingly, if the resin has high thixotropy before curing, it is difficult to appropriately fill the resin.

Therefore, the resins as materials of the first sealing resin **34** and the third sealing resin **36** preferably have higher thixotropy before curing than the resin as a material of the second sealing resin **35**. Note that, the resin as a material of the third sealing resin **36** may be the same as that of the first sealing resin **34**.

Since the second sealing resin **35** is formed after the first sealing resin **34** and the third sealing resin **36** are completely or substantially cured, the first sealing resin **34**, the second sealing resin **35** and the third sealing resin **36** are not mixed with each other. In other words, phosphor particles included in each of the first sealing resin **34**, the second sealing resin **35** and the third sealing resin **36** do not move into the other sealing resins.

Fourth Embodiment

The fourth embodiment is different from the first embodiment in that concave and convex portions on the substrate are used to arrange the light-emitting elements and the sealing resins. It should be noted that the explanation of the same features as the first embodiment will be omitted or simplified.

Structure of Light-Emitting Device

FIG. **5**A is a top view showing a light-emitting device **4** in the fourth embodiment. FIG. **5**B is a vertical cross-sectional view showing the light-emitting device **4** taken on line D-D of FIG. **5**A.

The light-emitting device **4** has a substrate **40** having a concave portion **47** and a convex portion **48** on the upper surface thereof, first light-emitting elements **41** placed on the bottom surface of the concave portion **47**, a convex-shaped first sealing resin **43** which has a closed annular shape in a top view and is provided in the concave portion **47** as well as above the concave portion **47** to seal the first light-emitting elements **41**, a second light-emitting element **42** arranged on the upper surface of the convex portion **48** which is surrounded by the first sealing resin **43**, and a second sealing resin **44** filled in a region surrounded by the first sealing resin **43** to seal the second light-emitting element **42**.

Either the first sealing resin **43** or the second sealing resin **44** includes phosphor particles, or the first sealing resin **43** and the second sealing resin **44** respectively include phosphor particles emitting different fluorescent colors. In the example shown in FIGS. **5**A and **5**B, the first sealing resin **43** and the second sealing resin **44** respectively include first phosphor particles **45** and second phosphor particles **46**.

The substrate **40** is, e.g., a circuit board or a lead frame inserted board.

The first light-emitting element **41** and the second light-emitting element **42** are the same light-emitting elements as the first light-emitting element **11** and the second light-emitting element **12** in the first embodiment.

Since the first light-emitting elements **41** and the second light-emitting element **42** are placed at different heights, light absorption between light-emitting elements is less likely to occur as compared to the first embodiment in which the first light-emitting elements **11** and the second light-emitting element **12** are placed at the same height.

Since the first light-emitting elements **41** are placed at the lower position than the second light-emitting element **42**, the amount of light emitted from the first light-emitting elements **41** toward the second light-emitting element **42** is larger than the amount of light emitted from the second light-emitting element **42** toward the first light-emitting elements **41**. Therefore, an emission wavelength of the first light-emitting element **41** is preferably longer than that of the second light-emitting element **42** in order to suppress absorption of light from the first light-emitting elements **41** by the second light-emitting element **42**. For example, when the second light-emitting element **42** is a blue LED chip, a green LED chip is used as the first light-emitting element **41**.

The first sealing resin **43** and the second sealing resin **44** are respectively formed of the same resins as the first sealing resin **13** and the second sealing resin **14** in the first embodiment.

Since the first sealing resin **43** is formed by stacking a resin above the concave portion **47**, thixotropy of the resin before curing is preferably high. When thixotropy is high, an increase in viscosity after formation is large and the shape thereof is thus likely to be kept until the resin is cured.

On the other hand, the second sealing resin **44** is formed by filling a region surrounded by the first sealing resin **43** with a resin using the first sealing resin **43** as a dam and then curing

the resin. Accordingly, if the resin has high thixotropy before curing, it is difficult to appropriately fill the resin.

Therefore, the resin as a material of the first sealing resin **43** preferably has higher thixotropy before curing than the resin as a material of the second sealing resin **44**.

Since the second sealing resin **44** is formed after the first sealing resin **43** is completely or substantially cured, the first sealing resin **43** and the second sealing resin **44** are not mixed with each other. In other words, phosphor particles included in each of the first sealing resin **43** and the second sealing resin **44** do not move into the other sealing resin.

Since the first sealing resin **43** is formed by filling the concave portion **47**, it is easy to control the shape as compared to the first sealing resin **13** in the first embodiment which is formed on the flat surface.

Manufacturing Process of Light-Emitting Device

An example of a manufacturing process of the light-emitting device **4** will be described below.

FIGS. **6**A to **6**C are vertical cross-sectional views showing a manufacturing process of the light-emitting device **4** in the fourth embodiment.

Firstly, as shown in FIG. **6**A, the substrate **40** having the concave portion **47** and the convex portion **48** on the upper surface thereof is prepared and the first light-emitting elements **41** and the second light-emitting element **42** are placed respectively on the bottom surface of the concave portion **47** and the upper surface of the convex portion **48**.

To form the substrate **40**, for example, the concave portion **47** may be formed by scraping the upper surface of a plate-like substrate or the convex portion **48** may be formed by stacking up a resin on the upper surface of a plate-like substrate.

Next, as shown in FIG. **6**B, a resin including the first phosphor particles **45** is filled in the concave portion **47** and is further stacked above the concave portion **47**, thereby forming the first sealing resin **43** which seals the first light-emitting elements **41**.

Next, as shown in FIG. **6**C, a resin including the second phosphor particles **46** is filled in a region surrounded by the first sealing resin **43** using the first sealing resin **43** as a dam and is then cured, thereby forming the second sealing resin **44** which seals the second light-emitting element **42**. Here, the resin of the second sealing resin **44** is filled after the first sealing resin **43** is cured to the extent that the first sealing resin **43** is not mixed with the resin of the second sealing resin **44**.

Fifth Embodiment

The fifth embodiment is different from the fourth embodiment in that the substrate includes plural convex portions each mounting the light-emitting elements. It should be noted that the explanation of the same features as the fourth embodiment will be omitted or simplified.

Structure of Light-Emitting Device

FIG. **7**A is a top view showing a light-emitting device **5** in the fifth embodiment. FIG. **7**B is a vertical cross-sectional view showing the light-emitting device **5** taken on line E-E of FIG. **7**A.

The light-emitting device **5** has a substrate **50** having a concave portion **57** and convex portions **58** on the upper surface thereof, first light-emitting elements **51** placed on the bottom surface of the concave portion **57**, a convex-shaped first sealing resin **53** which has annular portions **59** each having a closed annular shape in a top view and is provided in the concave portion **57** as well as above the concave portion **57** to seal the first light-emitting elements **51**, second light-emitting elements **52** arranged on the upper surfaces of the convex portions **58** surrounded by the annular portions **59** of the first sealing resin **53**, and second sealing resins **54** filled in regions surrounded by the annular portions **59** to seal the second light-emitting elements **52**.

A dotted line shown in FIG. **7**A conceptually shows one of positions of the annular portions **59** of the first sealing resin **53**. In the example shown in FIG. **7**A, three annular portions **59** each surrounding one convex portion **58** are included in the first sealing resin **53**. The second light-emitting elements **52** are placed on the three convex portions **58** surrounded by the annular portions **59**.

Either the first sealing resin **53** or the second sealing resin **54** includes phosphor particles, or the first sealing resin **53** and the second sealing resin **54** respectively include phosphor particles emitting different fluorescent colors. In the example shown in FIGS. **7**A and **7**B, the first sealing resin **53** and the second sealing resin **54** respectively include first phosphor particles **55** and second phosphor particles **56**.

The substrate **50** is, e.g., a circuit board or a lead frame inserted board.

The first light-emitting element **51** and the second light-emitting element **52** are the same light-emitting elements as the first light-emitting element **11** and the second light-emitting element **12** in the first embodiment.

Since the first light-emitting elements **51** are placed at the lower position than the second light-emitting elements **52**, the amount of light emitted from the first light-emitting elements **51** toward the second light-emitting elements **52** is larger than the amount of light emitted from the second light-emitting elements **52** toward the first light-emitting elements **51**. Therefore, an emission wavelength of the first light-emitting element **51** is preferably longer than that of the second light-emitting element **52** in order to suppress absorption of light from the first light-emitting elements **51** by the second light-emitting elements **52**.

The first sealing resin **53** and the second sealing resin **54** are respectively formed of the same resins as the first sealing resin **13** and the second sealing resin **14** in the first embodiment.

Since the first sealing resin **53** is formed by stacking a resin above the concave portions **57**, thixotropy of the before curing is preferably high. When thixotropy is high, an increase in viscosity after formation is large and the shape thereof is thus likely to be kept until the resin is cured.

On the other hand, the second sealing resin **54** is formed by filling a region surrounded by the annular portion **59** of the first sealing resin **53** with a resin using the annular portion **59** as a dam and then curing the resin. Accordingly, if the resin has high thixotropy before curing, it is difficult to appropriately fill the resin.

Therefore, the resin as a material of the first sealing resin **53** preferably has higher thixotropy before curing than the resin as a material of the second sealing resin **54**.

Since the second sealing resins **54** are formed after the first sealing resin **53** is completely or substantially cured, the first sealing resin **53** and the second sealing resins **54** are not mixed with each other. In other words, phosphor particles included in each of the first sealing resin **53** and the second sealing resins **54** do not move into the other sealing resin.

Sixth Embodiment

The sixth embodiment is different from the fifth embodiment in a pattern of the concave and convex portions on the substrate. It should be noted that the explanation of the same features as the fifth embodiment will be omitted or simplified.

Structure of Light-Emitting Device

FIG. **8**A is a top view showing a light-emitting device **6** in the sixth embodiment. FIG. **8**B is a vertical cross-sectional view showing the light-emitting device **6** taken on line F-F of FIG. **8**A.

The light-emitting device **6** has a substrate **60** having a concave portion **67** and convex portions **68** on the upper surface thereof, first light-emitting elements **61** placed on the bottom surface of the concave portion **67**, a convex-shaped first sealing resin **63** which has annular portions **69** each having a closed annular shape in a top view and is provided in the concave portion **67** as well as above the concave portion **67** to seal the first light-emitting elements **61**, second light-emitting elements **62** arranged on the upper surfaces of the convex portions **68** surrounded by the annular portions **69** of the first sealing resin **63**, and second sealing resins **64** filled in regions surrounded by the annular portions **69** to seal the second light-emitting elements **62**.

A dotted line shown in FIG. **8**A conceptually shows one of positions of the annular portions **69** of the first sealing resin **63**. In the example shown in FIG. **8**A, the first sealing resin **63** has a lattice-like shape in a plan view and the second light-emitting element **62** is placed on each of the convex portions **68** located in squares of the lattice.

Either the first sealing resin **63** or the second sealing resin **64** includes phosphor particles, or the first sealing resin **63** and the second sealing resin **64** respectively include phosphor particles emitting different fluorescent colors. In the example shown in FIGS. **8**A and **8**B, the first sealing resin **63** and the second sealing resin **64** respectively include first phosphor particles **65** and second phosphor particles **66**.

The substrate **60** is, e.g., a circuit board or a lead frame inserted board.

The first light-emitting element **61** and the second light-emitting element **62** are the same light-emitting elements as the first light-emitting element **11** and the second light-emitting element **12** in the first embodiment.

Since the first light-emitting elements **61** are placed at the lower position than the second light-emitting elements **62**, the amount of light emitted from the first light-emitting elements **61** toward the second light-emitting elements **62** is larger than the amount of light emitted from the second light-emitting elements **62** toward the first light-emitting elements **61**. Therefore, an emission wavelength of the first light-emitting element **61** is preferably longer than that of the second light-emitting element **62** in order to suppress absorption of light from the first light-emitting elements **61** by the second light-emitting elements **62**.

The first sealing resin **63** and the second sealing resin **64** are respectively formed of the same resins as the first sealing resin **13** and the second sealing resin **14** in the first embodiment. The resin as a material of the first sealing resin **63** preferably has higher thixotropy before curing than the resin as a material of the second sealing resin **64**.

Since the second sealing resins **64** are formed after the first sealing resin **63** is completely or substantially cured, the first sealing resin **63** and the second sealing resins **64** are not mixed with each other. In other words, phosphor particles included in each of the first sealing resin **63** and the second sealing resins **64** do not move into the other sealing resin.

Effects of the Embodiments

In the first to sixth embodiments, a dam for preventing a resin from flowing out is not present at boundaries between plural light-emitting portions each of which is composed of a light-emitting element and phosphor particles included in a sealing resin and emits a different color, and this allows area saving of the light-emitting device. In addition, since a dam is not formed at the boundaries between plural light-emitting portions emitting different colors, it is possible to simplify a manufacturing process of a light-emitting device provided with plural light-emitting portions emitting different colors as compared to the conventional art.

Although the embodiments of the invention have been described above, the invention is not intended to be limited to the embodiments and the various kinds of modifications can be implemented without departing from the gist of the invention. In addition, the constituent elements in the embodiments can be arbitrarily combined without departing from the gist of the invention.

In addition, the invention according to claims is not to be limited to the above-mentioned embodiments. Further, please note that all combinations of the features described in the embodiments are not necessary to solve the problem of the invention.

What is claimed is:

1. A light-emitting device, comprising:
- a first light-emitting element disposed on a substrate;
- a convex-shaped first sealing resin that comprises an annular portion formed in a closed annular shape in a top view and seals the first light-emitting element;
- a second light-emitting element disposed on the substrate in a region surrounded by the annular portion of the first sealing resin; and
- a second sealing resin filled in the region surrounded by the annular portion so as to seal the second light-emitting element,
- wherein one of the first and second sealing resin includes a phosphor particle or the first and second sealing resins include a phosphor particle to emit a different fluorescent color from each other, and
- wherein a resin material of the first sealing resin has a higher thixotropy before curing than a resin material of the second sealing resin.

2. A light-emitting device, comprising:
- a first light-emitting element disposed on a substrate;
- a convex-shaped first sealing resin that comprises an annular portion formed in a closed annular shape in a top view and seals the first light-emitting element;
- a second light-emitting element disposed on the substrate in a region surrounded by the annular portion of the first sealing resin; and
- a second sealing resin filled in the region surrounded by the annular portion so as to seal the second light-emitting element,
- wherein one of the first and second sealing resins includes a phosphor particle or the first and second sealing resins include a phosphor particle to emit a different fluorescent color from each other,
- wherein the substrate comprises a concave portion and a convex portion on an upper surface thereof,
- wherein the first light-emitting element is disposed on a bottom surface of the concave portion,
- wherein the first sealing resin is provided in the concave portion and above the concave portion, and
- wherein the second light-emitting element is disposed on an upper surface of the convex portion.

3. The light-emitting device according to claim **2**, wherein an emission wavelength of the first light-emitting element is longer than that of the second light-emitting element.

4. The light-emitting device according to claim **1**, wherein the second sealing resin is disposed between inner edges of the annular portion.

5. The light-emitting device according to claim **1**, wherein the convex-shaped first sealing resin seals only the first light-emitting element, and

wherein the second sealing resin seals only the second light-emitting element.

6. The light-emitting device according to claim **1**, wherein the second sealing resin contacts the second light-emitting element.

7. The light-emitting device according to claim **1**, wherein an upper edge of the first sealing resin and an upper edge of the second sealing resin are co-planar.

8. The light-emitting device according to claim **1**, wherein an inner edge of the annular portion of the first sealing resin contacts an outer edge of the second sealing resin.

9. The light-emitting device according to claim **1**, wherein an upper edge of the first sealing resin is exposed.

10. The light-emitting device according to claim **1**, wherein the first sealing resin is exposed.

11. The light-emitting device according to claim **1**, wherein the first sealing resin contacts the first light-emitting element, and

wherein the second sealing resin contacts the second light-emitting element.

12. A light-emitting device, comprising;

a first light-emitting element disposed on a substrate;

a convex-shaped first sealing resin that comprises an annular portion formed in a closed annular shape in a top view, wherein the first sealing resin seals and contacts the first light-emitting element;

a second light-emitting element disposed on the substrate in a region surrounded by the annular portion of the first sealing resin; and

a second sealing resin filled in the region surrounded by the annular portion so as to seal and contact the second light-emitting element,

wherein at least one of the first and the second sealing resins includes a phosphor particle to emit a different fluorescent color from each other, and

wherein a resin material of the first sealing resin has a higher thixotropy before curing than a resin material of the second sealing resin.

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